

## Stars, Galaxies, and the Universe

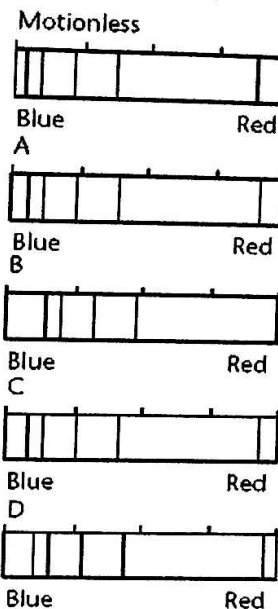
### How Far and How Fast?

You know that electromagnetic radiation is energy in the form of waves. Planets, stars, and galaxies emit electromagnetic radiation. As one of these objects moves through space toward an observer, the waves of electromagnetic radiation between the object and the observer move closer together. That is, the distance between the crests of the waves decreases, causing the wavelength to shorten. If that same object moved away from an observer, the waves between the object and the observer would move farther apart from each other. The distance between the crests of the waves would increase, and the wavelength would lengthen.

When a star is moving toward Earth very fast, the wavelength of its light shortens, causing it to appear slightly more blue than usual. If a star is moving away from Earth very fast, the wavelength of its light lengthens, causing it to appear slightly more red. By measuring this *blue shift* or *red shift* of light, astronomers can determine whether the star is moving toward or away from Earth, and how fast. To do this, astronomers use the shift of spectral lines produced by chemicals in the star's atmosphere. Astronomers can also use the spectrum of a galaxy to tell how fast the galaxy is moving toward or away from Earth.

Using the principle of red shift, Edwin Hubble studied the relationship between a galaxy's distance and the speed at which it moves away from Earth. He found that the farther away a galaxy is, the faster it moves away from Earth. This relationship is called *Hubble's Law*.

Based on the spectrums in the figure, rank the four galaxies in order of the speed with which they are moving away from Earth, from slowest (1) to fastest (4).



	Rank (1 = slowest, 4 = fastest)
Galaxy A	
Galaxy B	
Galaxy C	
Galaxy D	

1. Based on Hubble's Law, which of the galaxies is farthest from Earth?

2. Are any of the galaxies moving toward Earth? Explain.